

Claims

1. A thin film resonator (FBAR) ladder filter, comprising:

a plurality of serially-coupled FBAR elements provided in a die, each serially-coupled FBAR element including an upper metal electrode and a lower metal electrode;

a plurality of shunt-coupled FBAR elements provided on said die, each shunt-coupled FBAR element including an upper metal ground electrode providing a ground node and a lower metal electrode, at least one capacitor element provided on said die, each capacitor element including an upper metal electrode and a lower metal electrode, wherein each capacitor element is serially coupled between two ground nodes so that the inductive coupling of the shunt-coupled FBAR elements is compensated.
2. The ladder filter of claim 1, wherein only one single capacitor element is provided on said die.
3. The ladder filter of claim 1, wherein said die rests on a carrier or package that includes an external ground.
4. The ladder filter of claim 3, wherein said final external ground is on a carrier or package upon which said die rests.
5. The ladder filter of claim 1, wherein said upper and lower electrodes of the at least one capacitor element are thin film metallic members made out of aluminum and/or molybdenum and/or tungsten.

6. The ladder filter of claim 1, wherein said upper and lower electrodes of the at least one capacitor element and said upper and lower electrodes of the series-coupled and shunt-coupled FBAR elements are thin film metallic members made out of the same metal or metal layers.

7. The ladder filter of claim 1, wherein said upper and lower electrodes of the at least one capacitor element having an active piezoelectric material interposed therebetween, said piezoelectric material selected from the group comprising at least ZnO, CdS and AlN.

8. The ladder filter of claim 1, said upper and lower electrodes of the at least one capacitor element and said upper and lower electrodes of the series-coupled and shunt-coupled FBAR elements having the same active piezoelectric material interposed therebetween.

9. The ladder filter of claim 1, wherein the capacity of the capacitor element necessary for compensating the inductive coupling is designed by primarily adjusting the area of the upper metal electrode and lower metal electrode.

10. A duplexer, comprising:

a first port, a second port and a third port;

a first bandpass filter connected between the first port and the third port, the first bandpass filter including a first ladder circuit having shunt and series FBAR elements; and

a series circuit connected between the second port and the third port, the series circuit including a 90° phase shifter in series with a second bandpass filter, the second bandpass filter comprising a second ladder circuit having shunt and series FBAR elements, wherein at least one of the first and second ladder circuits comprises:

a plurality of serially-coupled FBAR elements provided in a die, each serially-coupled FBAR element including an upper metal electrode and a lower metal electrode;

a plurality of shunt-coupled FBAR elements provided on said die, each shunt-coupled FBAR element including an upper metal ground electrode providing a ground node and a lower metal electrode, at least one capacitor element provided on said die, each capacitor element including an upper metal electrode and a lower metal electrode, wherein each capacitor element is serially coupled between two ground nodes so that the inductive coupling of the shunt-coupled FBAR elements is compensated.

11. The duplexer of claim 10, wherein the first bandpass filter is a Tx filter and the second bandpass filter is a Rx filter.

12. The duplexer of claim 11, wherein the ladder circuit of the Rx filter comprises:

a plurality of serially-coupled FBAR elements provided in a die, each serially-coupled FBAR element including an upper metal electrode and a lower metal electrode;

a plurality of shunt-coupled FBAR elements provided on said die, each shunt-coupled FBAR element including an upper metal ground electrode providing a ground node and a lower metal electrode, at least one capacitor element provided on said die, each capacitor element including an upper metal electrode and a lower metal electrode, wherein each capacitor element is serially coupled between two ground nodes so that the inductive coupling of the shunt-coupled FBAR elements is compensated.

13. A method of grounding a ladder filter composed of a plurality of serially-coupled thin film resonator (FBAR) elements on a die, each pair of the plurality of serially-coupled FBAR elements having a FBAR element coupled in shunt therebetween, thus forming a plurality of adjacently shunt-coupled FBAR elements in the die, comprising:

connecting between the upper grounding electrodes of at least two adjacently shunt-coupled FBAR elements a capacitor element; and

connecting each adjacently shunt-coupled FBAR element to a final ground which is external to the ladder filter.

14. The method of claim 13, wherein said die rests on a carrier or package that includes said external ground.

15. A method of grounding a ladder filter, comprising:

providing a plurality of serially-coupled thin film resonator (FBAR) elements on a die, wherein each serially-coupled FBAR element includes an upper and lower metal electrode;

providing a shunt FBAR element between pairs of said plurality of serially-coupled FBAR elements, thus forming a plurality of adjacently shunt-coupled FBAR elements in the die, wherein each adjacently shunt-coupled FBAR element includes an upper ground metal electrode and a lower metal electrode;

providing at least one capacitor element between pairs of said shunt-coupled FBAR elements, wherein each capacitor element is serially coupled between two upper grounding electrodes so that the inductive coupling of the shunt-coupled FBAR elements is compensated;

connecting each upper metal ground electrode of said adjacently shunt-coupled FBAR element to a final ground which is external to the ladder filter.